Measuring and modeling maximum forest net C sequestration

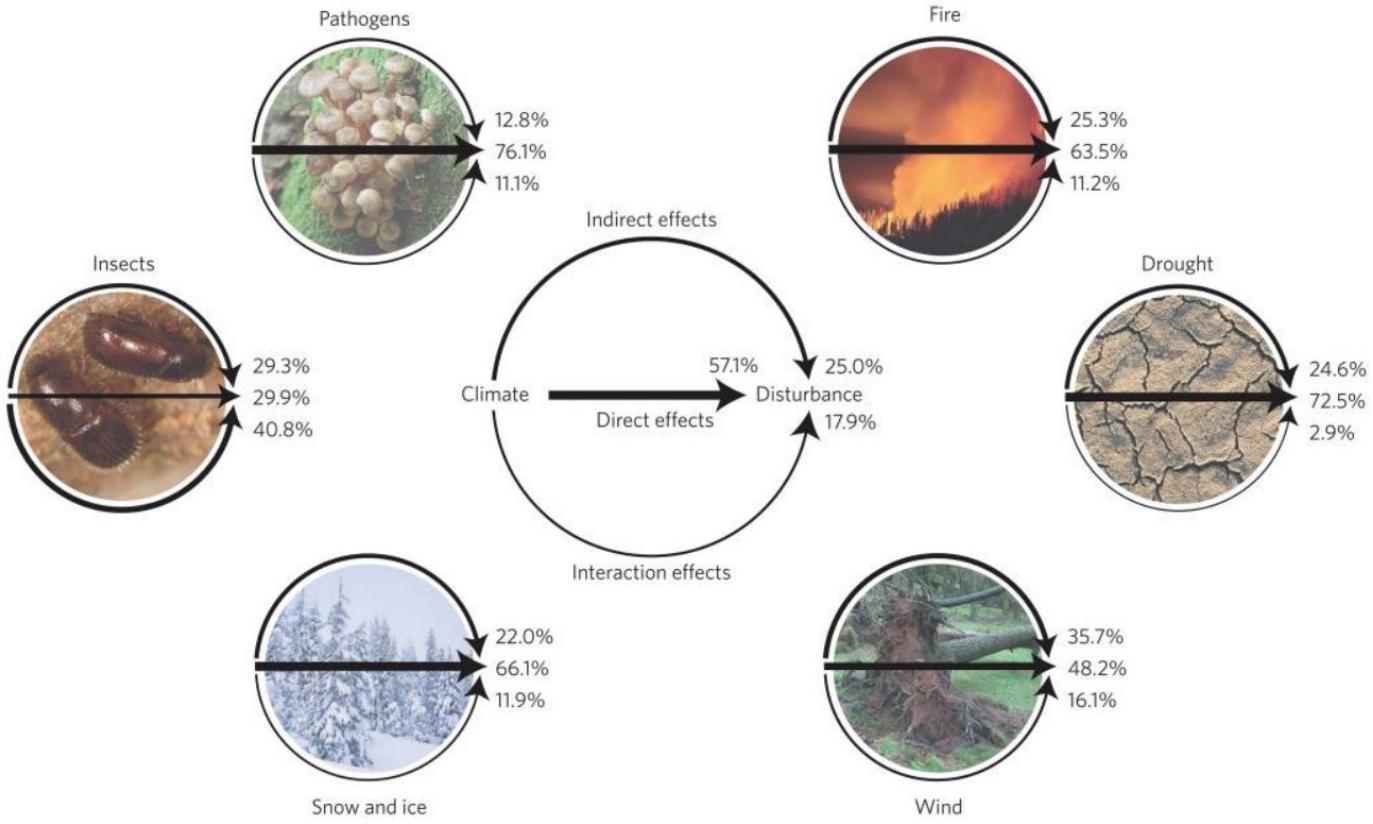
Manaswini Ganjam
Ph.D. Student
Under the guidance of Dr. Stith Thompson Gower & Dr. Justin Baker
Department of Forestry and Environmental Resources
North Carolina State University
Email: mganjam@ncsu.edu

Biomass storage vs carbon sequestration

Significant scaling up of removal of atmospheric CO_2 is emphasized in different modeled pathways to meet the Paris agreement and climate stabilization targets (IPCC, 2022)

Disturbances in forest ecosystems are potential threats to carbon storage

Feedback mechanisms due to climate change affect optimal forest net carbon sequestration



Seidl et al., 2017

Objectives of the study

To estimate the maximum net C sequestration potential for the southeastern United States using dominant forest ecosystems measured chronosequence data

Hypotheses:

1. Forest net ecosystem productivity (NEP) dynamics during stand development is similar to Odum, 1969 hypothesized model.
2. Forest C management science must include vegetation and soil/detritus.

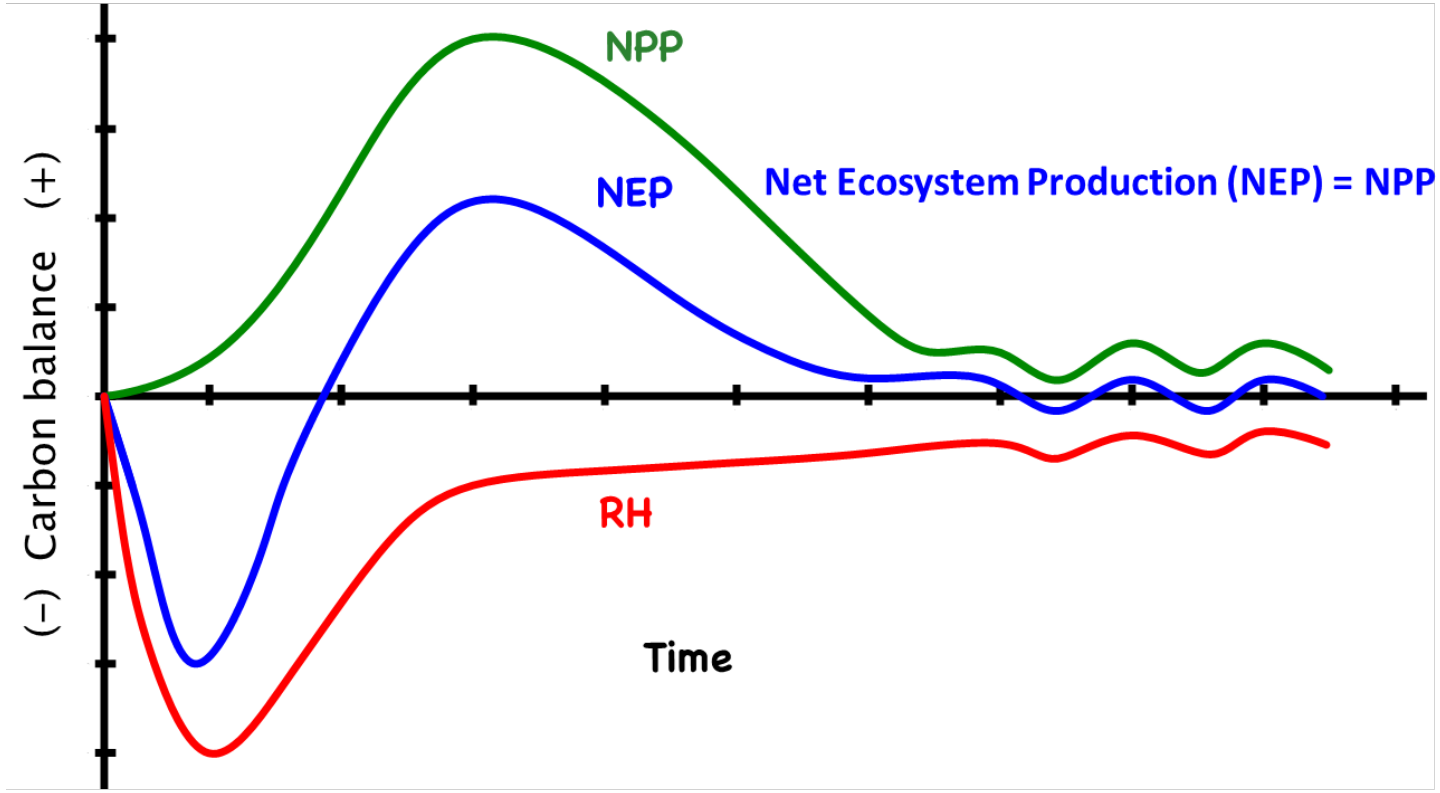
Background: Carbon storage and sequestration statistics

	1990	2005	2016	2017	2018	2019	2020
LULUCF Emissions[c]	31.4	41.3	35.4	45.5	39.8	30.3	53.2
LULUCF CH_4 Emissions	27.2	30.9	28.3	34.0	30.7	25.5	38.1
LULUCF N_2O Emissions	4.2	10.5	7.1	11.5	9.1	4.8	15.2
LULUCF Carbon Stock Change[e]	(892.0)	(831.1)	(862.0)	(826.7)	(809.0)	(760.8)	(812.2)
LULUCF Sector Net Total[f]	(860.6)	(789.8)	(826.6)	(781.2)	(769.3)	(730.5)	(758.9)

EPA, 2022

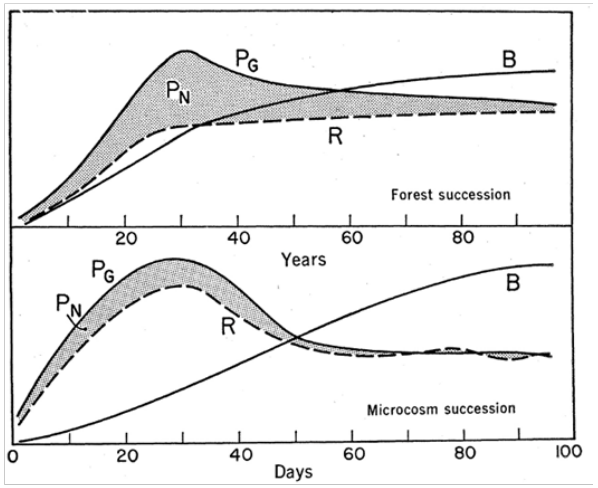
Odum, 1969 Theory and model

NPP = annual C sequestered from the atmosphere and stored in Vegetation (stem, foliage, roots, etc.)



Net Ecosystem Production (NEP) = NPP - RH

Heterotrophic respiration (HR) = annual C lost from the soil to the atmosphere due to decomposition



NEP and measuring NEP

Net Ecosystem Production denotes the net accumulation of organic matter or carbon by an ecosystem;

- ***NEP*** *= [Rate of production of living organic matter (**NPP**)] – [Heterotrophic respiration, (**RH**)]*
- ***RH*** is the decomposition rate of dead organic matter.

Study approach:

- Accounting for ***RH*** in traditional growth and yield models
- Incorporating soil carbon dynamics in forest carbon management models
- Measuring forest NEP through chronosequence data acquisition

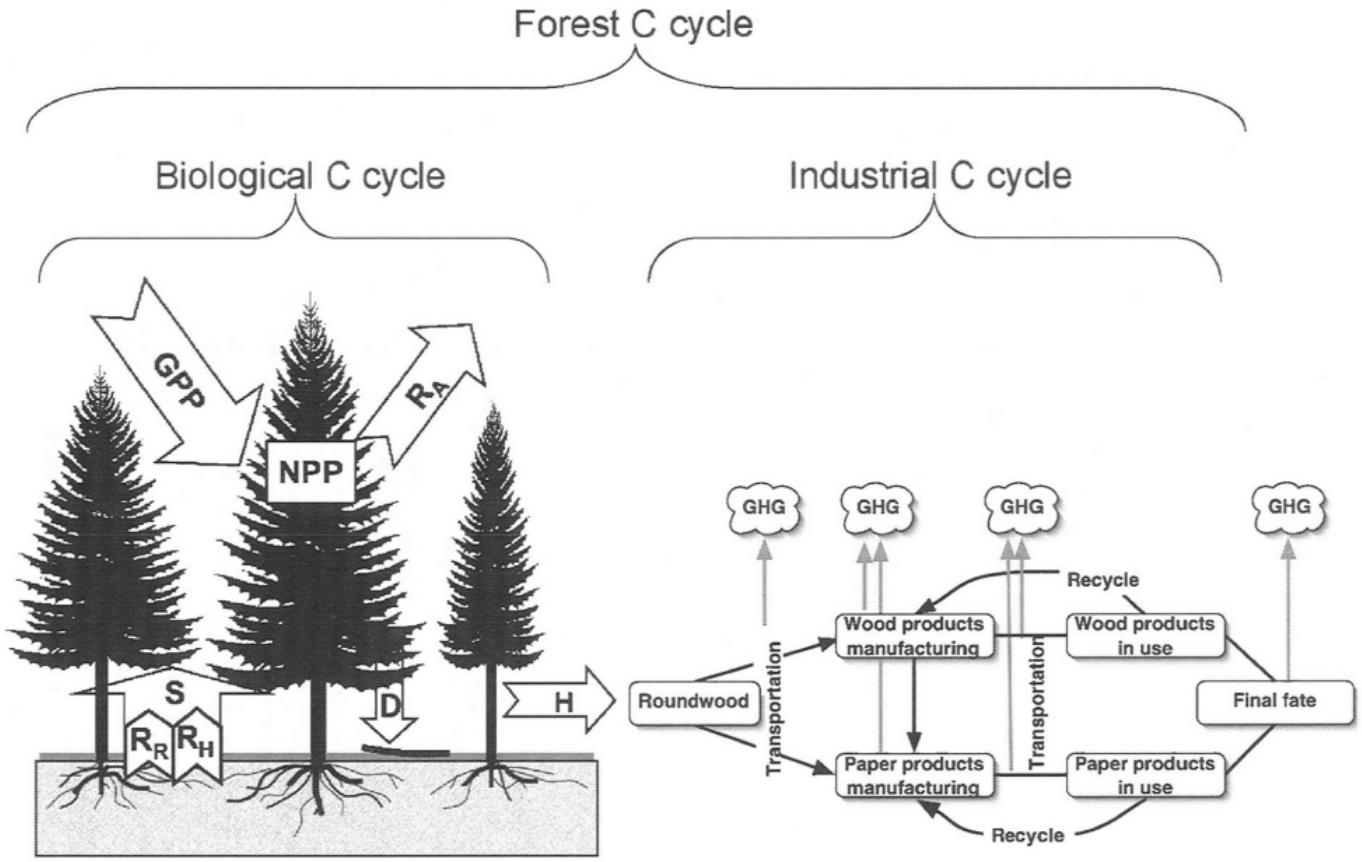
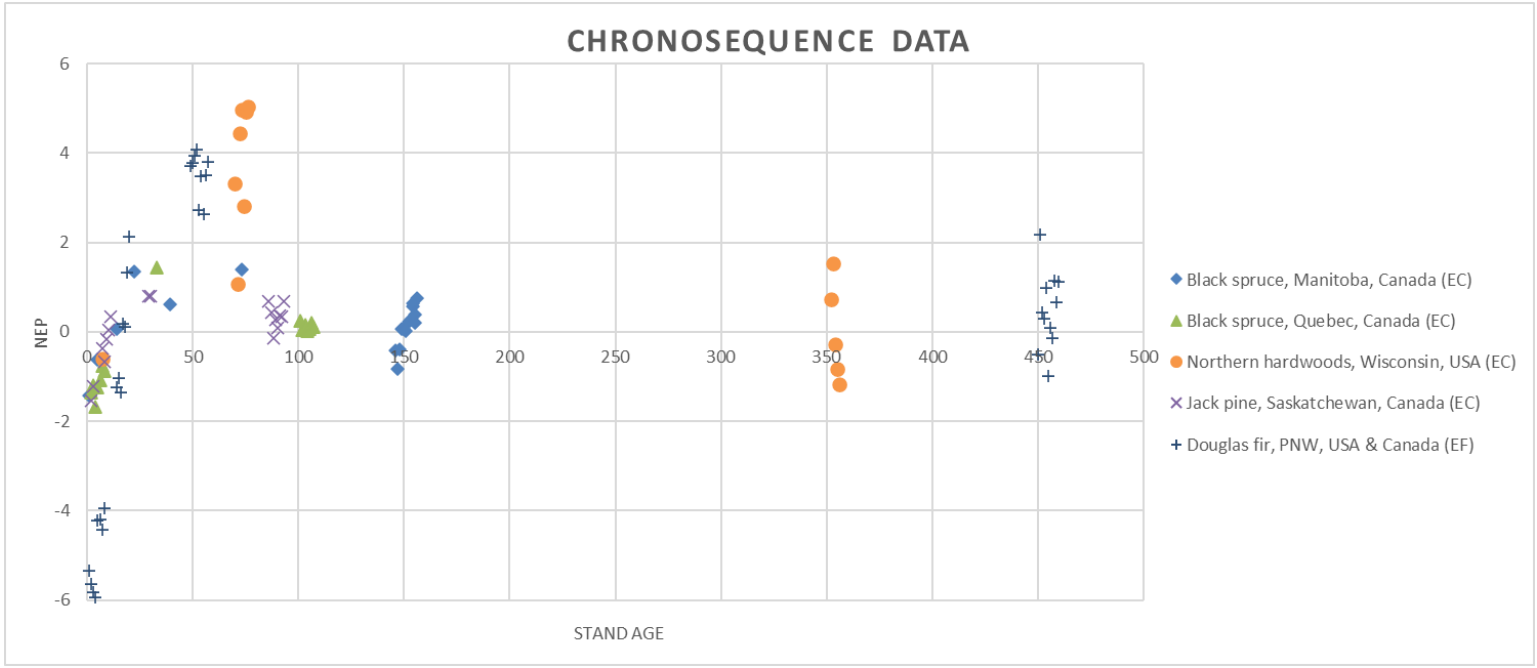


Figure: Gower, 2003

Methodology

- Develop a model of NEP variation with respect to the stand age based on available chronosequence data
- Extend the model to southeast forest species – drawing inference from other regions
- Quantify peak NEP and convergence to zero as a function of relative stand age
- Relative stand age vs NEP graph
  - Polynomial fit for the chronosequence data
  - Limitations: data gaps

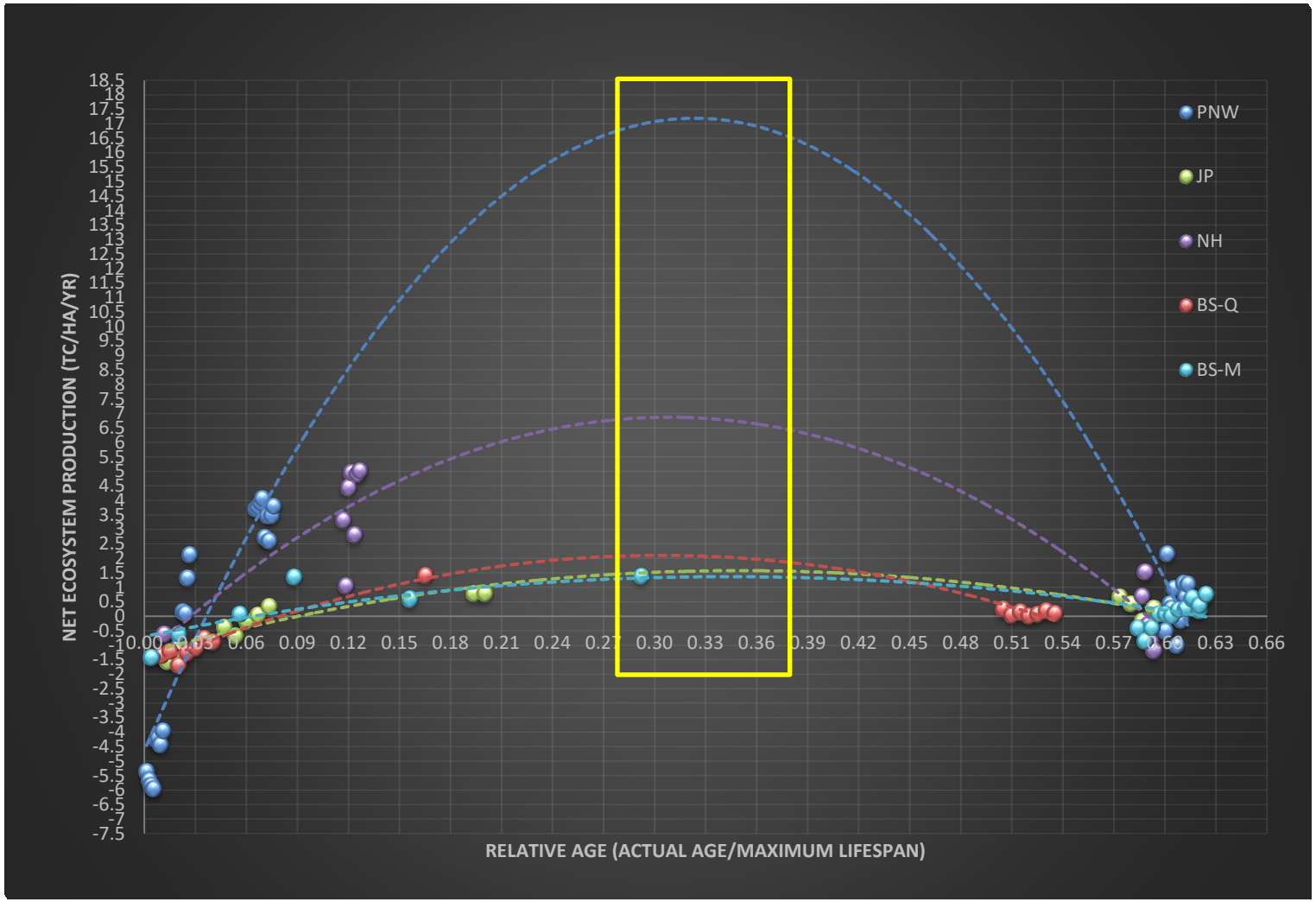


Next steps:

- FIA data to extrapolate the results derived from the theory corroborated using the chronosequence data

Conclusions

- The five forest chronosequence data support Odum's hypothesized model.
- For stands ages between 1-11 the average carbon loss per year for five forest ecosystems is -1.54 tC/ha, emphasizing the requirement to include soil C dynamics.
- Peak NEP values range between the relative stand ages: 0.27 -0.39
- Forest C science management that focuses on C sequestration, versus C storage, will remove more CO_2 from the atmosphere



Project funded by: Jordan Family Foundation
to Professor Stith T. Gower

Thank you